Climate SMART Agriculture
Climate Action Today = Food for Tomorrow

Keeley Holder
May 23, 2018
SCIENCE ONLY explains what happens in nature
CLIMATE CHANGE & AGRO-METEOROLOGY
Our context...

‘Rainfall is King’

‘For Agriculture rainfall is king’

Since rainfall is a climate quantity whose amounts, intensity and duration will vary and possibly change...

Vulnerability
Science Supports It

Our science supports consideration of the issue by suggesting

Significant *variability* in Caribbean rainfall
(seasonal through decadal)

Translates into significant *variability* in water availability
Variability – ‘Irregular short (year to year)’
Variations that interrupt Seasonality

ENSO - El Niño-Southern Oscillation

- Is a global coupled ocean-atmosphere phenomenon.
- El Niño (La Niña) is an unusual warming (cooling) of the tropical Pacific Ocean.
- The Southern Oscillation is an accompanying fluctuation in the air pressure difference between Tahiti and Darwin, Australia.
- Prompts changes in weather patterns across the globe.
- Occurs irregularly at approximately 3-6 year intervals.
Variability – ‘Irregular short (year to year)’

Variations that interrupt Seasonality

1. Dry season drier in south Caribbean
   Changes large scale circulations

2. Late wet season drier in most of the Caribbean

3. Early wet season drier in most of the Caribbean
   Warms Caribbean Sea

Increases shear
Variability – ‘Irregular long (decadal or more)’

NAO

Positive phase => Drier Caribbean (particularly eastern Caribbean)

Negative phase => Wetter Caribbean (particularly eastern Caribbean)
Variability

Thought 1
Context Commands It

Thought 2
Science Supports It

Thought 3

Climate Studies Group Mona | Department of Physics
Future Depends on It

Climate Change

If our context commands consideration of the issue
Vulnerability...

Then our science supports consideration of it by
suggesting how the vulnerability will play out
Variability...

And our future demands consideration of it as
climate change has and will continue to alter
rainfall and other parameters (significantly) on
long timescales
Viability...
### Climate Change

#### Climate Change Picture

| Temperatures       | Increase to end of century  
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td></td>
<td>1-4 degrees</td>
</tr>
<tr>
<td></td>
<td>Warmer nights and days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rainfall</th>
<th>Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>More intense storms</td>
</tr>
<tr>
<td></td>
<td>Drying by end of century</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sea Level Rise</th>
<th>Rising sea levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Erosion, inundation and storm surge</td>
</tr>
<tr>
<td></td>
<td>1 m or 2 m...Hmmmm?</td>
</tr>
</tbody>
</table>
Drought Outlook for the End of July
CariCOF’s Drought Alert Map

Current update (April 2018):
We continue to see no drought concern developing throughout most of the region. Exceptions are:

A drought watch is issued for Antigua, N Bahamas, SE Belize, W Cuba, French Guiana, Guadeloupe, St. Maarten, St. Kitts, central Suriname, Tobago, Virgin Is.

Long term drought outlook
Concerns by the end of the dry season (May 31st, 2018)?

- This 12-month SPI-based drought outlook uses observations through March 2018, with potential impacts on large surface water reserves and groundwater. In general, impacts are expected if the 12-month SPI is ≤ -0.8 (moderately dry or worse – ref. CDPMN).
- A drought warning is in effect for St. Maarten / St. Martin, Suriname, SE Haiti.
- A drought watch is in effect for ABC Islands, Antigua, N & SE Belize, W Cuba, N French Guiana, N French Guiana and Virgin Is.
AGRICULTURE & THE ENVIRONMENT
Soil is ‘BLACK’ Gold
FARMERS

GUARDIANS of the Environment
FARMERS of the Health & Wellness of Nation
## SOIL DEPLETION

### 1940 vs. 1991

Reduction in average mineral content of fruits and vegetables between 1940 and 1991

<table>
<thead>
<tr>
<th>MINERAL</th>
<th>VEGETABLES</th>
<th>FRUITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>-49%</td>
<td>-29%</td>
</tr>
<tr>
<td>Potassium</td>
<td>-16%</td>
<td>-19%</td>
</tr>
<tr>
<td>Magnesium</td>
<td>-24%</td>
<td>-16%</td>
</tr>
<tr>
<td>Calcium</td>
<td>-46%</td>
<td>-16%</td>
</tr>
<tr>
<td>Iron</td>
<td>-27%</td>
<td>-24%</td>
</tr>
<tr>
<td>Copper</td>
<td>-76%</td>
<td>-20%</td>
</tr>
<tr>
<td>Zinc</td>
<td>-59%</td>
<td>-27%</td>
</tr>
</tbody>
</table>
PESTICIDE ABUSE

The Pesticide Cycle

- Pesticides
- Absorbed by crop
- Leached below root zone by rain or irrigation
- Degraded by ultraviolet light
- Vaporized to atmosphere
- Adheres to soil particles
- Degraded by bacterial oxidation or chemical hydrolysis
- Surface run off to lakes and rivers
- Leached to water courses
- Deposited by rainfall
<table>
<thead>
<tr>
<th>Nutritional Factor</th>
<th>Grain-Fed Beef</th>
<th>Grass-Fed Beef</th>
</tr>
</thead>
<tbody>
<tr>
<td>Added Hormones</td>
<td>Usually</td>
<td>No</td>
</tr>
<tr>
<td>Fed Antibiotics</td>
<td>Usually</td>
<td>No</td>
</tr>
<tr>
<td>Fed Grain</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Omega-3 Fatty Acids</td>
<td>0.10</td>
<td>1.22</td>
</tr>
<tr>
<td>Omega-6 Fatty Acids</td>
<td>3.10</td>
<td>1.08</td>
</tr>
<tr>
<td>CLA</td>
<td>0.21</td>
<td>1.46</td>
</tr>
<tr>
<td>Beta Carotene</td>
<td>41.00</td>
<td>87.00</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>1.30</td>
<td>5.30</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>10.00</td>
<td>52.00</td>
</tr>
<tr>
<td>Total Fat</td>
<td>High &amp; Saturated</td>
<td>Perfect Balance</td>
</tr>
</tbody>
</table>
Nature, to be commanded, must be obeyed.

~ Francis Bacon
WITH GREAT POWER COMES GREAT RESPONSIBILITY...

BIG Responsibility
CLIMATE SMART AGRICULTURE IN PRACTICE
CSA OBJECTIVES

✓ Sustainably increasing productivity & incomes

✓ Adapting to climate change

✓ Reducing greenhouse gas emissions
There is **NO** “ONE BEST WAY” to farm.

It’s about the **“BEST FIT”** for your **purpose**.
CSA THROUGH PRODUCTIVITY
“Productivity growth through research & development in agriculture & food technology have been responsible for the dramatic increase in average yields by improving machinery & equipment and increasing technological efficiencies, such as the use of new fertilizers (organic & inorganic), feeds, seed varieties, automated irrigation management, life cycle analysis and postharvest management.”
PRODUCTIVITY

USA: 1950 vs 2000

OUTPUT
• each farmer = 12 times more farm output /hr

COWS
• avg. milk = 5,314 lbs / yr to 18,201 lbs / yr

CORN
• Avg. corn = 39 bushels/acre to 153 bushels /acre
GROWER ATTITUDE

why settle for competence...

EXCELLENCE

Competence

Communication

Passion

Innovation

Vision

Inspiration

Ideas

Motivation
“A business is a repeatable process that makes money. Everything else is a hobby.”

— Paul Freet, serial entrepreneur
“Technology is only as good as its TALENT.”
GROWER SKILL

Photosynthesis

Respiration

Transpiration
PRODUCTIVITY
IN FIELD GROWING
Maize growth stages

**Important disease and stalk borer control**

**Critical moisture requirement**

**Top dressing**

**Weed control**

<table>
<thead>
<tr>
<th>Days after emergence</th>
<th>V0</th>
<th>V2</th>
<th>V5</th>
<th>V8</th>
<th>V10</th>
<th>V12</th>
<th>V14</th>
<th>VT</th>
<th>R1</th>
<th>R2 to R3</th>
<th>R3 to R4</th>
<th>R5 to R6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Germination and emergence</strong></td>
<td>7</td>
<td>21</td>
<td>32</td>
<td>38</td>
<td>44</td>
<td>49</td>
<td>56</td>
<td>63</td>
<td>70</td>
<td>84</td>
<td>91</td>
<td>105</td>
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<tr>
<td><strong>Plant population established. Growth point 20mm - 25mm below surface. Five-leaf; cob and tassel initiation</strong></td>
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<tr>
<td><strong>Cob development</strong></td>
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<td><strong>Active growth; leaves and cob development; grace root development. 12-leaf; cob size determined</strong></td>
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<td><strong>Pollination; five to 10 days</strong></td>
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<td><strong>Kernel development</strong></td>
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<tr>
<td><strong>Grain filling; nutrients transported to cob</strong></td>
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<tr>
<td><strong>Physiological maturity – end of mass gain</strong></td>
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<tr>
<td><strong>Ready for harvest – 14% moisture</strong></td>
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* The number of days varies between growth classes and environments.
3- to adapt the variety (early – med. – late)
## AVERAGE Nutrient Content [Nitrogen (N), Phosphate (P\textsubscript{2}O\textsubscript{5}) And Potassium (K\textsubscript{2}O)] for Selected Organic Materials

<table>
<thead>
<tr>
<th>Product</th>
<th>N</th>
<th>P\textsubscript{2}O\textsubscript{5}</th>
<th>K\textsubscript{2}O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish meal</td>
<td>10</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Bone meal</td>
<td>3</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td><strong>Dried Commercial Manure Products</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken</td>
<td>1.5</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>Cattle</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Pigs</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

- These composition values are approximates ONLY because ranges in nutrient concentration exist for any organic material.
- The mineralization (decay) rate will vary with material.
- Materials with high N or P concentrations and rapid decay rates should be used carefully because of greater potential for pollution if nutrients are leached.
Nutrient Uptake Rates for Tomatoes

* - (source: Huett 1985)
1. Using the correct amount
2. Applying using **proper schedule & method of placement**

- Leads to reduced profits when it does not contribute to greater yields or improved fruit quality.
- Recent research with vegetables & strawberries shows reduced yields & reduced fruit quality with excess N.
- Excess N can lead to more disease, and for tomato, to more damage from insects such as thrips.
Optimal Growth: 1 inch / acre / week = 28,314 gallons
Phytomonitoring is the operational information channel based on direct measurement of plant water state and growth.
Mechanization & Farm Hands:

1 hand = 26 acres vs 1 hand = 2 acres
PRODUCTIVITY IN PROTECTED STRUCTURES
GROWING IN SOIL

POSITIVES
- Low cost

NEGATIVES
- Rainfall helps to leach harmful salts out of the soil
- With no rainfall, harmful salts can build up in the soil causing toxicity
Hello Hydroponics!
Drip System

- Rockwool slab - 100cm x 15cm
- Rockwool cube - 7.5cm

A. Nutrient tank stores nutrient
B. Nutrient pump circulates nutrient
C. Nutrient fed via drippers which restrict flow of nutrient to 2-9 litres per hour
D. Nutrient dripped onto grow medium (Rockwool)
E. Unused nutrient flows back into tank
Flood and Drain

A. Nutrient tank stores nutrient
B. Nutrient pumped through one way valve
C. Nutrient slowly flows back into nutrient tank through valve
Nutrient Film Technique

A. Nutrient tank stores nutrient
B. Nutrient pump circulates nutrient
C. Nutrient flows into grow channel
D. Nutrient absorbed by plant roots
E. Unused nutrient flows back into tank
60% more plants in horizontal vs vertical
GROWTH RATE FACTORS

- High light intensity = faster growth
- High temp = increased photosynthesis, respiration
- High humidity = decreased transpiration, increased pathogens (diseases)
- Low air flow = decreased transpiration, photosynthesis

A rapidly growing crop under good growing conditions is going to need more nutrients over the same period of time than one under slow growing conditions.
Integrated Pest Management

Agro-technical: sanitation

Physical: Insect-proof screenings, sticky traps, UV absorbing films

Chemical: selective pesticides (IGRs, botanicals)

Biological: resistant strains, biological controls
Western flower thrips - adult female
Three *Orius* nymphs

An adult & 2 nymphs

Commercial package

Eggs & Nymph of *Orius*
Two-spotted spidermite - adult, nymphs and egg
A female predator (*Phytoseiulus*)

Predator in action

Results of predation

Commercial package
Build up of $\text{Na}^+,$ $\text{Cl}^-$, $\text{K}^+$, $\text{Ca}^{2+}$ over time in water will require water to be changed (dumped)

Inorganic Fertilizers

- Good growers = every 6-8 weeks
- Poor growers = every 2-4 weeks

Commercial organic fertilizers: $>6$ months
- Removes 50% factors impacting yield
- Uses 10% water of soil-based farms
- Uses 20% fertilizer of soil-based farms
- 1.5X more plants per m²
- 2.5X more crops per year
PRODUCTIVITY IN POST HARVEST MANAGEMENT
FRESH PRODUCE

ALIVE

LOSES MOISTURE

BREATHES

RELEASES HEAT

CAN EVEN DIE

CAN GET SICK
POSTHARVEST LOSSES

Harvesting = severing the umbilical cord
Postharvest losses = 50%-80% in developing nations

Rules of Thumb:

- For every hour field heat is not removed from produce, we lose 1 day of shelf life
- For every 10°C increase in temperature, rate of decay increases 2X – 3X
- Cool produce down to 7/8 cool time for optimum shelf life
FORCED AIR COOLING
COOLBOT

Build your own walk-in cooler with a CoolBot & an air conditioner
Reduce Electricity Use in Cold Storage and Forced-Air Coolers

- Maximize use of refrigerated volume.
- Install efficient lighting.
- Improve refrigeration system efficiency.
- Minimize exterior heat gain.
- Minimize fan electricity use.
Thank You